The Story of Stone is the latest addition to the resource material produced by the Wolli Creek Preservation Society.

It's a valuable introduction to the geology of sandstone, the vegetation of the sandstone ridges surrounding the valley, Aboriginal and early European settlers' use of stone, quarrying techniques, and the importance of sandstone as a fine durable building material.

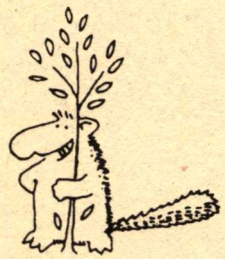
The booklet demonstrates the link between the natural and the built environment and provides some background to the continuing struggle to save the Wolli Valley from tollways and other commercial enterprises. Teachers, students, residents, and visitors to the valley will find it a valuable source of information and a starting point for further research and study.

ISBN 0 949871 43 5

Other Wolli Creek resources...

- **Trees of Wolli Creek** (booklet)
- **Birds of Wolli Creek** (booklet)
- **Too Precious to Pave** (12 minute video)
- **Save Energy, Save Sydney** (self contained portable display on the energy-saving advantages of public transport—available for community events)

Available from the Wolli Creek Preservation Society, PO Box 270 Earlwood, NSW 2206



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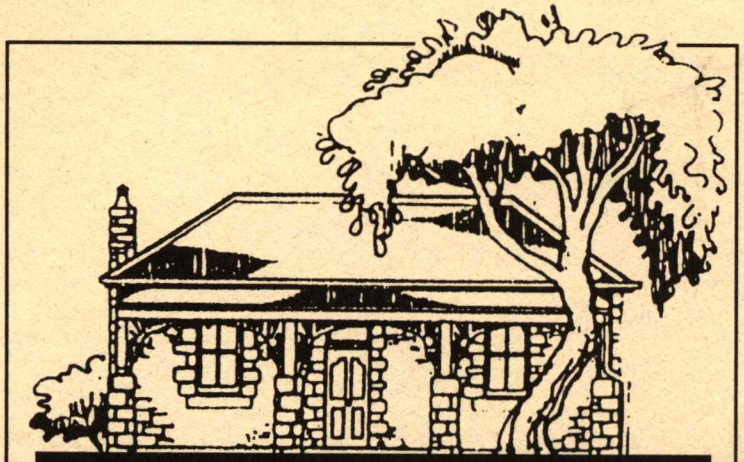
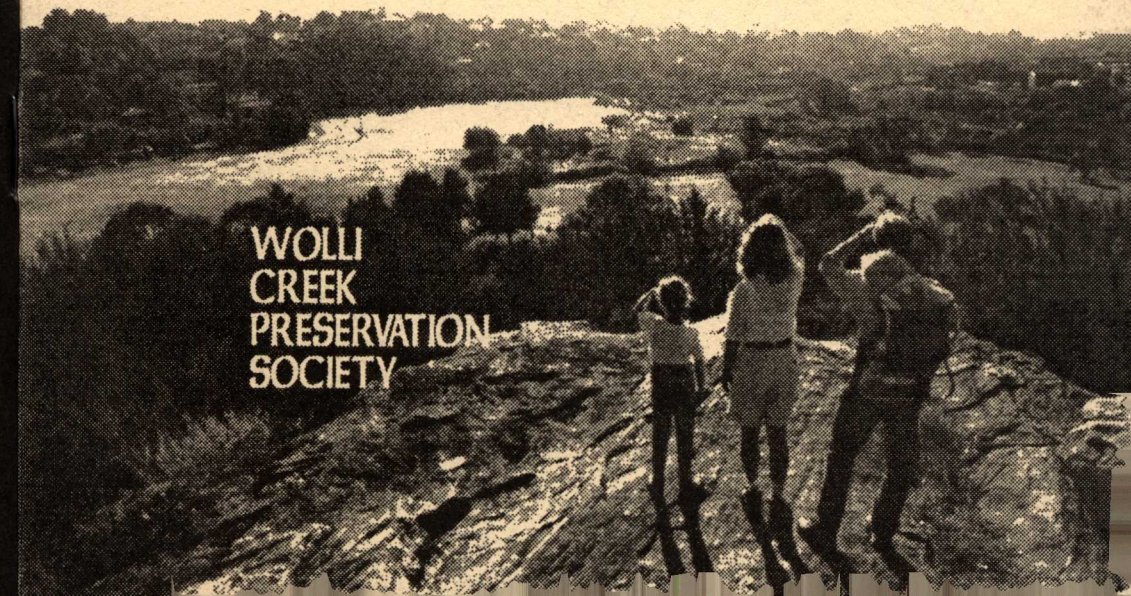
The Story of Stone



The Story of Stone

IN THE WOLLI CREEK VALLEY



The Story of Stone

IN THE WOLLI CREEK VALLEY

Research and writing by George Morgan

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Editorial assistance: Judy Finlason, Debra Little & Peter Stevens

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WOLLI CREEK PRESERVATION SOCIETY INC.

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Foreword

A popular theme in recent years for heritage activities has been 'Our Hidden Heritage'. The Wolli Creek Valley typifies the 'hidden heritage'.

As one of the thousands of daily commuters on the East Hills railway line, I view the willows and vegetation—much of which consists of exotic plants—along the creek as welcome visual relief to the industrial areas between Tempe and the City.

Occasionally, my attention is caught by water birds on the creek. At such times I contemplate an expressway cutting a swathe through the valley and I reflect on the heritage hidden behind the willows threatened by this nightmare of ill-considered transport planning.

Unlike most of my fellow travellers I have walked the Wolli Valley, painstakingly assessed and identified the vegetation and closely observed the ongoing bush regeneration and restoration work.

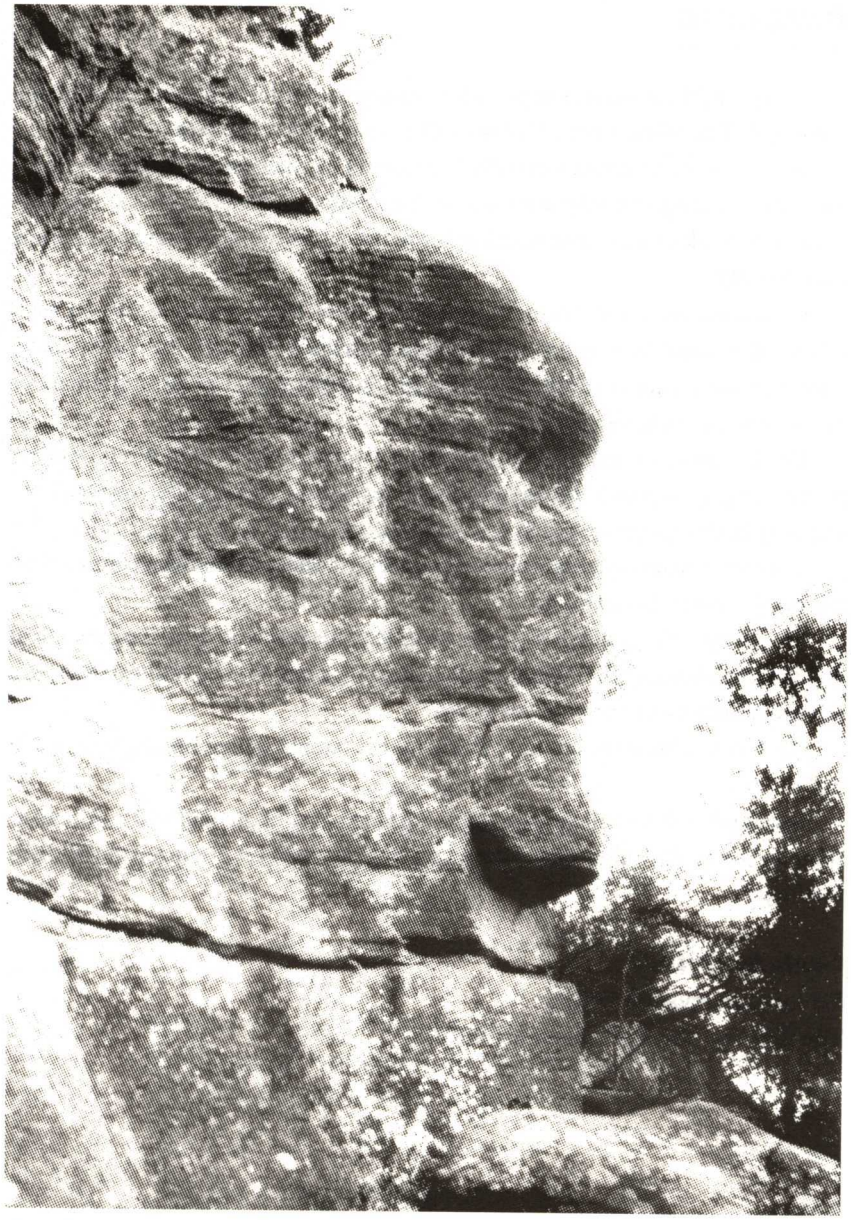
But my own understanding and appreciation of the area has been restricted by limited historical background.

The Story of Stone in the Wolli Creek Valley fills this void from the geological and geomorphological viewpoint to the human history of occupation and finally the social history of more recent years.

All this has been intriguingly linked to the 'stone' theme highlighted in the title.

I commend this publication to all those who have fought and will continue to fight for the Wolli Valley and to the many who have not yet glimpsed the 'Hidden Heritage'.

Graham Quint
Senior Conservation Officer
The National Trust of Australia (NSW)



The Escarpments beside the bush-track, Earlwood. PHOTO Melinda Menning

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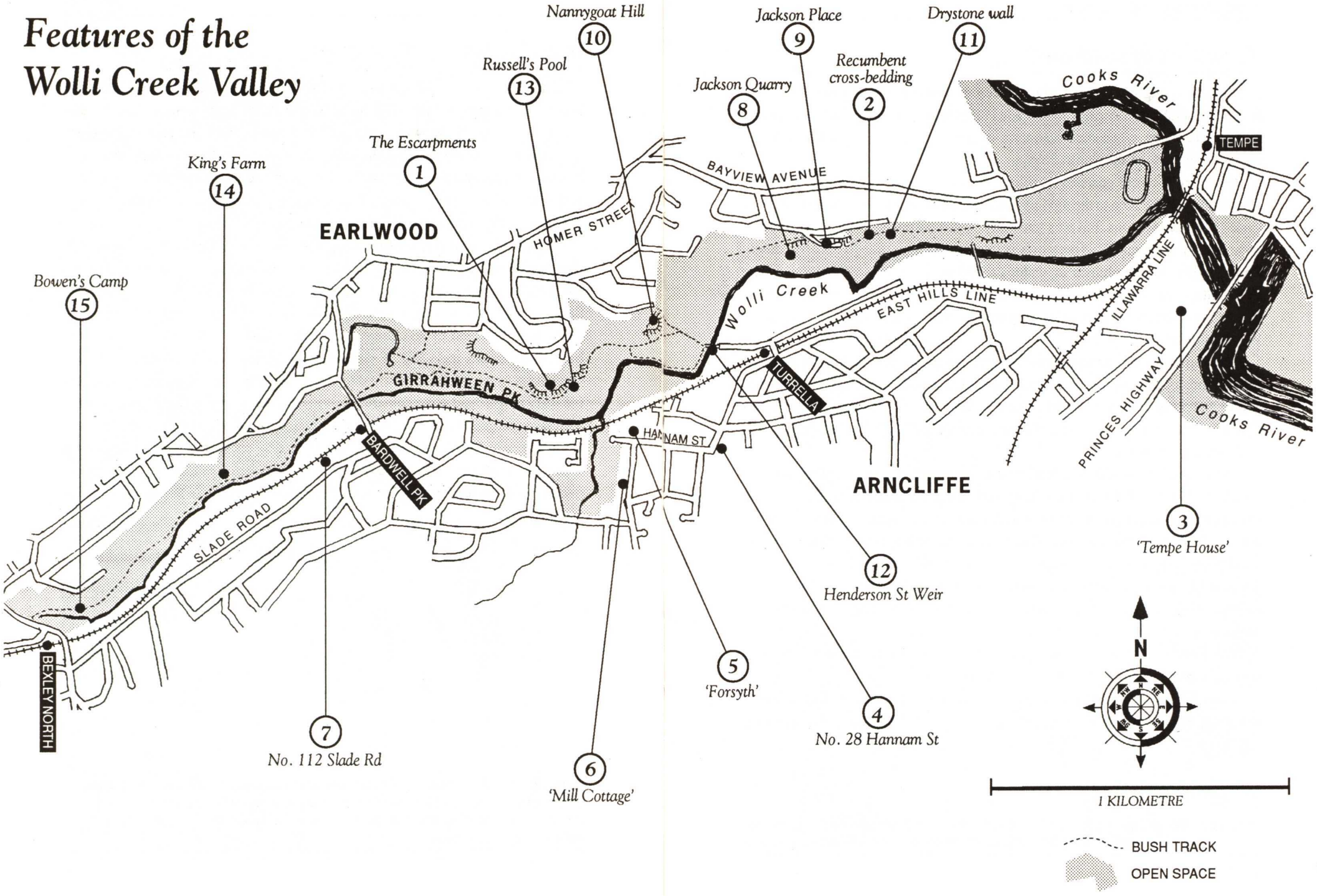
Introduction

The Wolli Creek Valley is one of the most important areas of urban bushland in the Sydney region. The valley has since the 1950s been earmarked as one site along which the F5 Freeway could run. As a consequence, residential development has not been permitted in the valley. A wealth of native flora and fauna can be observed around Wolli Creek. The valley provides valuable habitat for birds and many other native animals. It contains fine examples of remnant Sydney bushland including heaths, woodlands, reedbeds and mangroves.

Those who visit the Wolli Valley and the nearby Cooks River area will observe the numerous sandstone outcrops and escarpments, some of them quite spectacular, which surround the waterways. They are comprised of Hawkesbury Sandstone, the principal geological formation in the Sydney region. Most of the city's two thousand or so square kilometres stand on a sandstone shelf. This booklet describes the story of sandstone: its formation, its importance to the vegetation in the Wolli Valley and its use as a fine durable building material for the early houses and other constructions in the area. It also describes the ways in which sandstone is quarried, worked and transported. Key features of the local landscape are identified and illustrated. In this booklet we aim to increase appreciation of some of these features which we generally allow our eyes to pass over without understanding the natural processes and human labour which goes to form them.

Sandstone crossbeds can be seen clearly in this photo of The Escarpments. Two rockbolts placed by rockclimbers are evident here—this form of recreation is creating new threats to the rock surfaces and vegetation in the valley. PHOTO: Judy Finlason

Features of the Wolli Creek Valley



Formation of sandstone

A walk along the Wolli Valley takes us through the ancient sandstone formations laid down during the Triassic Period which began approximately 237 million years ago when the Australian continent was part of Gondwana and situated towards the the South Pole.

During millions of years a vast river flowed over the area that is now Sydney. Similarities can be seen to the modern Brahmaputra River in Bangladesh. Its flow varied with the seasons, but was generally high-volume and cold and carried a great deal of sediment. This pattern was interrupted from time to time by 'mega-floods' when huge volumes of water carried vast amounts of sediment. The sediments were deposited, buried and compressed to become the Hawkesbury Sandstone which is so familiar in many parts of the Sydney region, including the Wolli Valley.

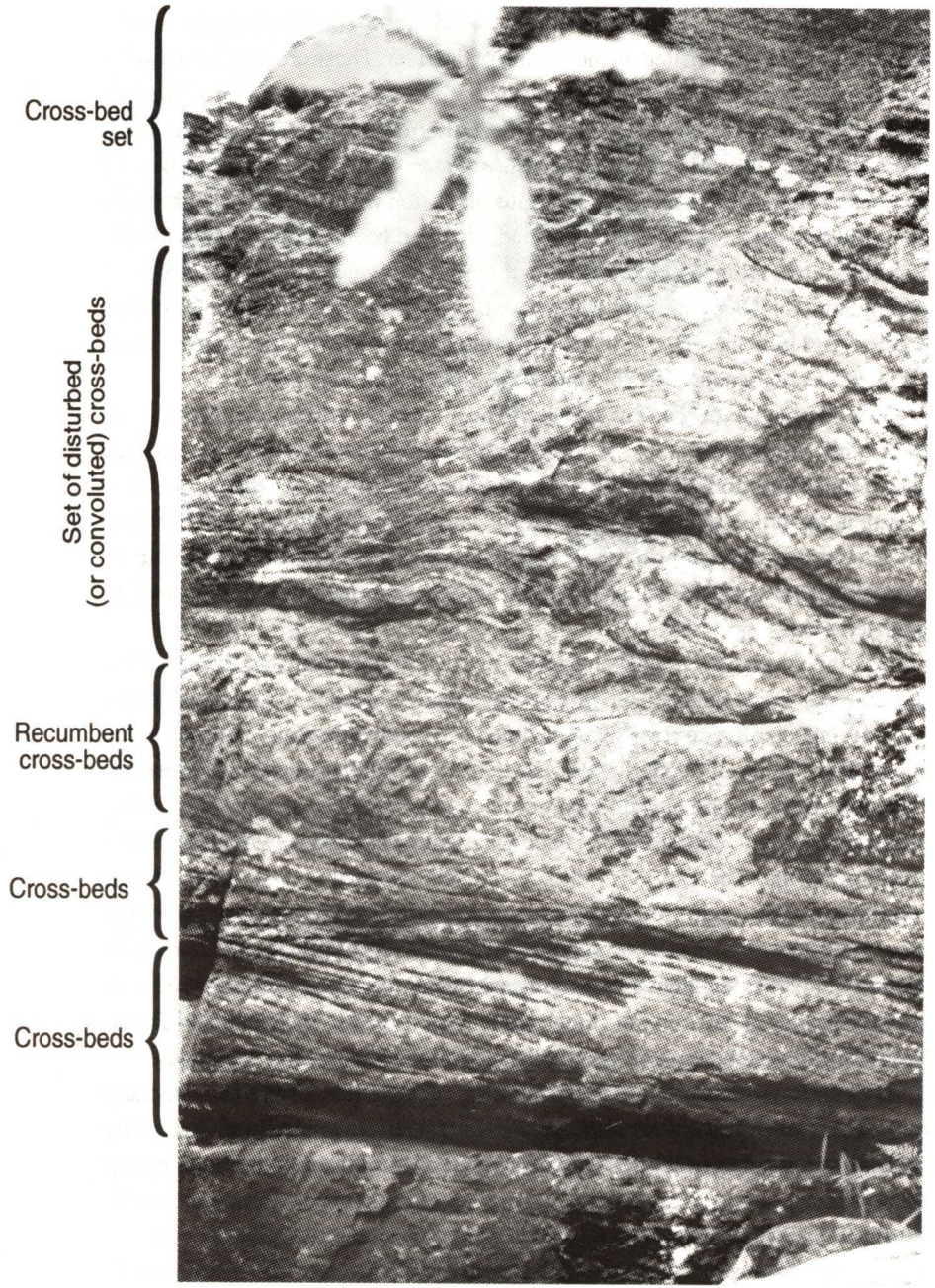
Geologists have learned to read the pages of the history of this mighty river in the sandstone rocks that it left behind working on the assumption that basic geological processes were much the same in the past as they are now. On this basis it is possible to work out what the past must have been like to explain the landforms we now see.

In this section we will briefly illustrate some parts of that detective work, in which the Wolli Valley has its own special place. To understand it we need to examine the general processes by which sandstone is formed and some of the details of the shape that such rock formations take. This is not only interesting in itself but is also of economic importance. Sandstone is commonly porous and permeable, and sandstone formations host approximately half the world's known reserves of petroleum (oil and natural gas) and most of the world's artesian- and ground-water.

We have included an appendix to this booklet which explains in more scientific detail the processes by which sandstone is formed.

The best place in the Wolli Valley to see a variety of sandstone formations is along the bush-track between Girrahween Park and Nannygoat Hill (see map ref.1).

This east-facing rock surface at The Escarpments is an excellent place to view a variety of different sandstone formations. PHOTO: Merrick Plater.

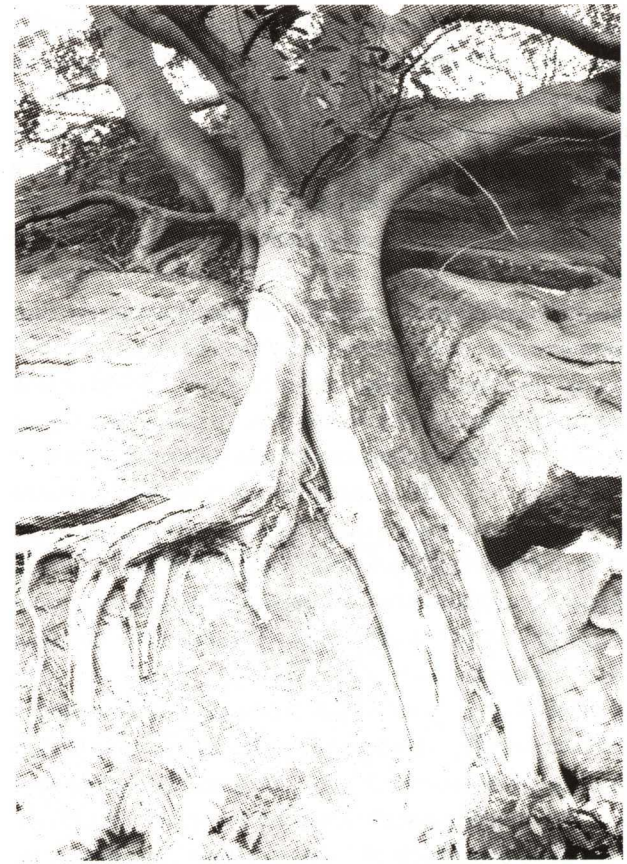


There are excellent examples of cross-bedding formed by underwater sand dunes as sand was deposited on the bottom of the river. These cross-bedded layers (i.e. cross-bed sets) vary in thickness from a few centimetres to up to 7 metres depending on the flow of the river. A further pattern in the stone called recumbent cross-bedding occurred when cold dense water carrying a large amount of sediment flowed down the river. This caused friction with the bottom of the river and pulled over the tops of the cross-beds that had been laid down previously. Careful observation of cliff faces in the valley reveal several examples of recumbent cross-bedding; however, recently one of the largest examples of this type of structure has been identified at the eastern end of the valley below Highcliff Road, Undercliffe, beyond Jackson Place (see Map ref. 2).

Another feature of the Hawkesbury Sandstone is the widespread presence of thick and extensive bodies of almost structureless stone know as massive sandstone. These formations are a result of huge floods, when large amounts of sediment including mudstone blocks were dumped on the bottom of the river as the flow of the river slowed down. Examples of this massive sandstone can be seen along the bush-track through the valley, both in natural outcrops and in quarried areas.

The colour and texture of sandstone are a result of the differing composition of the stone and depends on the mix of clay, quartz, feldspar and other minerals. Weathering, erosion, and the passage time have created dramatic patterns in the stone. The quality of stone dictated its value as a building material. 'Massive' sandstone is finely grained and incorporates a large quantity of clay. This makes it relatively easy to cut into what is known as dimension stone, which is ideal as building blocks. The City of Sydney is situated on what is some of the finest sandstone in the world. Many of our major public buildings were constructed from sandstone that has an orange-yellow hue and is colloquially known as 'yellowblock'. This stone is often grey when first cut but gradually adopts its yellowish tinge as the minerals in the stone are exposed to the elements. Cross-bedded sandstone being harder and coarser grained, is used for flagstones.

Hawkesbury Sandstone has a sparkling effect. This effect is especially noticeable when freshly-exposed surfaces are viewed in sunlight. Each tiny flashing mirror is the face of a quartz crystal produced during the cementing process.



The strong wedging action of plant roots slowly breaks up the sandstone —this tree is a Port Jackson Fig (Ficus rubiginosa)

Soil and vegetation in sandstone regions

The sandstone regions in the Sydney area support a quite remarkably rich diversity of plants.

They are the home of what many of us recognise as Sydney's characteristic bush. Familiar in this diversity are the twisted forms of the Smooth Barked Apples (*Angophora costata*), the rich honey-like smell of Tick Bush (*Kunzea ambigua*), the pink or red spider-like flowers of Grevilleas (*Grevillia speciosa*) and the Old Man Banksia (*Banksia serrata*).

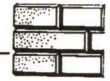
The sandy soil which results from the breakdown of Hawkesbury Sandstone is very poor in minerals, the nutrients essential for the growth and health of many

plants. This is particularly the case on ridges and slopes. After a few early abortive attempts to farm these soils, the unsuitability of them for European-style agriculture was soon recognised. This infertility, coupled with later difficulties associated with building on many sandstone areas, has proved to be the saviour of a significant amount of the sandstone vegetation of the Sydney region. By contrast, the clay soil vegetation of western Sydney is on flatter land, more suited to agriculture, and has been so extensively cleared that less than 2 per cent of the original natural vegetation remains.

Sydney's sandstone-derived soils are not only low in plant nutrients, but are also very acidic and very shallow (bedrock is often not far below the surface). Because of its sandy composition water drains through the soil very quickly. The region's plants have had to adapt to these conditions and to exposure to hot, drying winds and frequent fires, the latter often a function of Aboriginal management of the bush. The forest, woodland and heathland plants which have survived under these tough conditions, have evolved a variety of special adaptive features to cope with them, and in fact have prospered. These adaptive features include small, narrow, thick or leathery leaves to minimise water loss, special root structures and associations with soil fungi which maximise the uptake of available nutrients, and hard seed cases which enable seeds to survive fire.

While bushland on Hawkesbury Sandstone is still relatively well represented in the Sydney region, it is nevertheless sensitive and susceptible to any changes which occur to its soil 'life-support' system. Urban development on and adjacent to this bushland has brought a number of such changes. These include increased stormwater runoff (containing high levels of nutrients, from lawn fertilisers, roads, pet droppings and detergents, among other things) as well as changes to, and restrictions on previous regimes of burning. Many plants which are adapted to sandstone-derived soils do not cope with high nutrient levels, and the higher nutrient levels support exotic weeds and garden plants that would otherwise find the soil inhospitable. Bushland regeneration programs have been established in many areas in Sydney in response to these impacts.

While the vegetation of the Wolli Valley has some unique features, it is generally representative of Sydney sandstone plants. Over 200 species of native plants have been recorded in the valley. These in turn provide a habitat for the more than one hundred and fifty species of birds that have been recorded. This rich variety of plants can be seen growing in pockets of soil on, or between, exposed sandstone rocks, in thin layers of sandy soil on rock ledges, on rock



surfaces (in the case of mosses and lichens) and sometimes defying gravity by growing outwards from cliff faces—the plants' exposed roots growing into crevices and gripping the cliff face.

Plants are quite a strong force in the weathering of sandstone, and ultimately the production of the sandy soil which supports plant life. The strong wedging action of plant roots can break up sections of rock, and the acid secretions of plants dissolve the cementing material in the sandstone.

Many of these features of sandstone vegetation are observable by those who walk along the bush-track from Girrawheen Park to the summit of Nannygoat Hill. And not all the drill holes that can be seen in the sandstone boulders are caused by rock climbers! The small drill holes in the face of some sandstone boulders lining the summit track to Nannygoat Hill, for example, are the work of wasps. These solitary wasps are members of the Sphecidae family, a large family of wasps with many species.

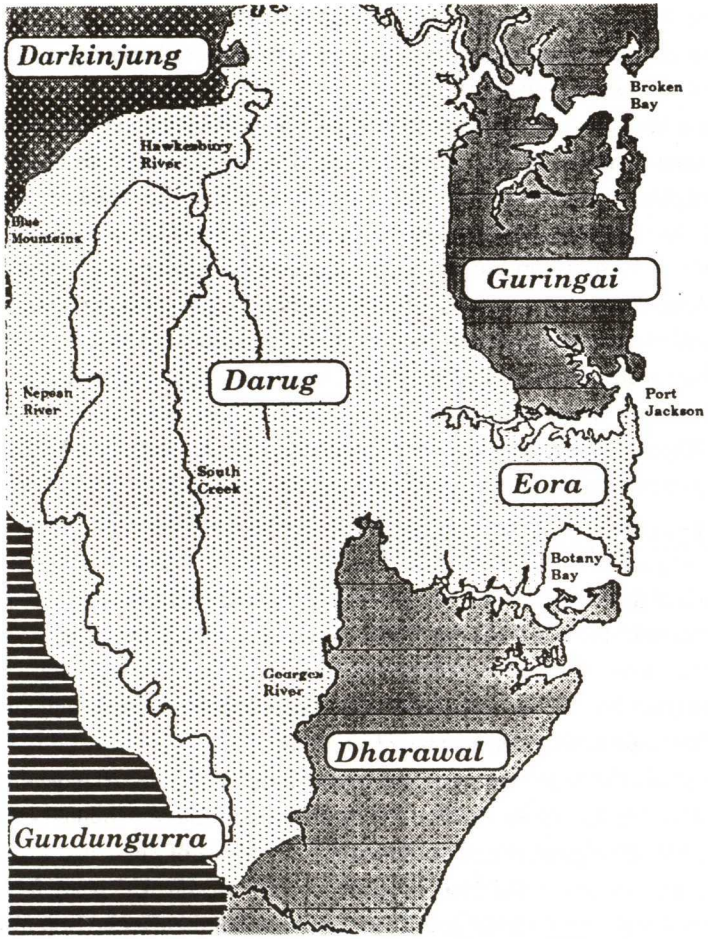
The Darug and Eora people

The Sydney region was the home of the Darug and Eora tribes prior to British colonisation of the area, with the Wolli Valley being the home of the Gweagal clan. The arrival of Captain Arthur Phillip saw the start of a bloody conflict between colonists and the traditional owners of the land on a scale and intensity which has been overlooked by many historians.

The British brought with them a legal system and an attitude to land which was completely foreign to Australian Aborigines. As a mainly 'hunter-gatherer' society, the Aboriginal people for countless thousands of years had learned to manage and conserve the land in order to gain sustenance from it. Under Aboriginal law no individual could own territory, but their social organisation, culture and rituals are inextricably linked to their traditional tribal lands.

After 1788 the allocation of parcels of land to ex-convicts and free settlers, with no acknowledgement of Aboriginal rights to the land, effectively deprived the Aborigines of their birthright and their ability to live a traditional lifestyle. In addition the disastrous smallpox epidemics of the 1790s virtually destroyed the Darug and Eora people.

The fertile Sydney region had been abundant in food. Aborigines had hunted, fished and gathered bush tucker. When the settlers took up land they naturally preferred the prime areas of alluvial land next to rivers and creeks, where the soil was richest for cultivation or for grazing livestock. The enclosure of areas, such



Aboriginal tribes of the Sydney area (after Kohen 1985).

as that adjacent to Wolli Creek, through the nineteenth century and the violence used to defend those areas, denied those Aborigines who were not killed in the conflict, access to sacred sites, shelters and food sources.

Although written historical records provide scant information about Aboriginal culture in the Sydney region, we can speculate that sandstone outcrops and overhangs around Wolli Creek, such as that which can be found along The Escarpments (Map ref. 1) and below Highcliff Road, (Map ref. 2) would have served as shelters and meeting places for Aborigines. The word 'Wolli' is

understood to have the Aboriginal meaning of 'camping place'. The name Wolli Creek first appeared on a map drawn up in 1834 .

A survey by Tranby College, in 1986, identified 24 rock shelters and two middens. It was thought that five of the shelters were worth further investigation. Rock carvings such as those that exist throughout the Sydney region may well have been present in the Wolli Valley, however extensive quarrying throughout the area would have doubtless destroyed these valuable sites. Only one remainder of the Aboriginal occupation of the area, apart from middens, is known. These are white foot and hand paintings, situated in a cave in the sandstone cliffs on the Cooks River side of Undercliffe. In order to preserve this important site the exact location is kept from public knowledge.

Middens at the base of Nannygoat Hill, with constantly exposed shell fragments, give an indication of the food eaten by the local tribes. Aborigines may have constructed fishing weirs from stone in the tidal reaches of Wolli Creek, as was a common practice in other areas.

The smooth sandstone surfaces would have been used as a grindstone to sharpen stone tools made from harder stone obtained elsewhere in the region, such as the gravel sands of the Hawkesbury-Nepean area. Simple stone tools were used for shaping wood and bone tools, and others were ground with sandstone into chopping tools and hatchet heads. Around Sydney thousands of grooves cut into the sandstone by this Aboriginal grinding process can still be seen.

Hopefully, in the future, archeological investigations will be carried out in the Wolli Valley which may give us a better understanding of the Aboriginal people who lived in the area.

Early European settlement

Finding suitable building materials was an essential task for the members of the First Fleet in Sydney Cove. Captain Cook's journal had recorded that the stone in the Cooks River area was 'sandy and very proper for building'. Early settlers came to realise that the best of Sydney 'yellowblock' sandstone provided building material of a standard unrivalled almost anywhere in the world. It can be cut in any direction and is smooth and durable. The most important early site for quarrying sandstone was at Pyrmont. During the nineteenth century commercial quarries were opened at Kent Street in the city, at Willoughby, Belmore, Waverley, Marrickville and Arncliffe. Later, Maroubra, Bondi and Canterbury were the location of quarries as were Bundanoon and Gosford outside Sydney.

A large proportion of Sydney's most important public buildings were constructed of sandstone. Included amongst these are the Sydney Town Hall, Saint Andrew's Cathedral, the GPO in Martin Place, the Mitchell Library, the State Art Gallery, the Lands Building, the Customs House, the Maritime Services Board building (now the Museum of Contemporary Art) and several of the buildings at Sydney University.

Sandstone dwellings around the Wolli Valley

While many of the early European settlers in the Wolli Creek area built dwellings out of sandstone, very few of them remain. Near the spot where 'Tempe House' now stands, a modest sandstone house was built around 1828 by Alexander Brodie Spark on land on the western side of Cooks River, which he had purchased from William Packer (Map ref. 3). The sandstone building contained six main rooms with extensive grounds containing gardens and orchards.This original cottage was demolished in 1836 to make way for 'Tempe House', designed for Spark by well known architect of the day John Verge. The grand mansion has survived a colourful history and now forms part of the 'Qantek' estate.

We are fortunate to have in the diary of Brodie Spark, published in *The Respectable Sydney Merchant - A.B. Spark of Tempe*, the following excerpts from April and May 1836 with their reminiscences of earlier days which help recreate the spirit of the times, and life in the old stone house.

> [13 April 1836] [Held] a good dinner in the new house and we were all very joyous...the evening passed delightfully with song, catch and glee. When crossing the river the Canadian Boat Song was struck up. I stood on the wharf listening to the receding sound, which flowed sweetly over the smooth water in the stillness of the night.
>
> [30 April 1836] ...Work on demolition begun on Tempe, two chimnies thrown down for the sake of their materials, but I still stick to the old Cottage, and sleep there in spite of innovations.
>
> [2 May 1836] There is a time even the Rats will forsake an old building. On my return to Tempe found the very stones of my verandah torn up and carried away, on entering my bedroom found it empty, my very bed had disappeared, and although I dined and passed the evening there, I was obliged to retire and rest in the new house. Lamented this destruction in remembering the many happy days and mirthful nights I and my friends had passed there, and sighed to think that the place that knows me now shall ere long know me no more.
>
> [8 May 1836] Sunday Constant showers throughout the day. The old cottage has been entirely pulled down and nearly all the rubbish removed. I have lived many years in it contentedly and happily and the new building has been erected less for myself than for others. Could the antient fabric have related the various scenes that have passed within it, it would have been a mirthful and moving tale. Mr and Mrs Duguid retired thither after their marriage, and there two of their children were born. It was the retreat of Mr and Mrs White on a similar occasion. It is ripe with the memory of the old Baillie as we stiled Mr McVitie, the burning of the Boots, and all his interminable puns and stories... the Major shone in full resplendence, there rung the laugh of Duguid, the loudest that one may hear joined by the Humourist in full chorus, there Mrs Duguid's sweet voice, with the piano accompaniment charmed the hearer, there the blind Traveller descanted, the Soldier fought o'er his battles, the Sage and Politician brooded over the fate of the rising empire, the Divine, the Newspaper Editor, the Doctor, the Skipper, the Lawyer, the man in office and the man of no office, occasionally mingled in harmony, and long it were to tell, if possible, the diversity of disposition, talent, rank and moral worth, that there for a time a found pleasant asylum...
>
> [9 May 1836] The windows of Heaven seemed to have opened in right earnest. Day and night the waters splashes abundently and with but little intermission.

A large portion of the land on the southern bank of Wolli Creek, in what is now Turrella, was allocated to Reuben Hannam. He came to NSW as a convict and worked on the brickyards on Brickfield Hill between Goulburn and Bathurst Streets in the city. His hard work and diligence impressed Governor Macquarie who brought Hannam's wife and family out from England and allocated Reuben 100 acres adjacent to Wolli Creek. The property covered a large area between Wolli Creek and Wollongong Road in the vicinity of Hannam Street. Hannam made little use of the property other than to erect a small two-roomed sandstone cottage.

When part of the estate was later acquired by W.C. Wentworth, he installed his relative William Bucknell to manage it. A substantial stone residence 'Willowdene' was built for the Bucknell family and Hannam's original small dwelling was used as a kitchen for the main house. Both buildings were demolished around 1930 to make way for the construction of the East Hills railway line.

'Forsyth' in Turrella is one of the best known of the Wolli Valley's stone cottages. PHOTO: Melinda Menning.

Among the oldest of the dwellings that are still standing in the Wolli Valley area is the cottage which was built in the 1840s and occupied by Reuben's grandson, Fred Hannam (Map ref. 4). Situated at 28 Hannam Street on what was part of Hannam's original grant, this small cottage was intended to be the kitchen for a larger house which in the end was never built. When the current occupants bought the property 10 years ago it was in a derelict state. The rebuilding at the front of the house means that the only original walls that can be seen are at the side of the house.

One of the grandest of the sandstone houses is 'Forsyth' at 57 Hannam Street (Map ref. 5). This was built towards the end of the last century by Samuel Jeeves, who ran a wool-scouring business on the flats bordering Wolli Creek at the rear of his property. The house has a high pitched roof and two storeys. The hall on the ground floor was laid with huge rectangular blocks of sandstone. Jeeves later developed interests in dairy farming, stone quarrying and house building in and around the Arncliffe district.

One of the finest examples of sandstone construction is 'Mill Cottage' which

'Mill Cottage', a fine example of the stonemason's craft, is one of the area's oldest houses. PHOTO: Judy Finlason.

stands at 29 John Street (Map ref. 6). It took its name from the proximity of a windmill which used to stand in the grounds and was used to pump water. The house has been extensively renovated but the ashlar (smooth-faced) blocks of this house are a fine example of the stonemason's craft.

A local historian, Arthur Ellis, recalls that Mr Blackwell, who lived in a tiny cottage next to Mill Cottage, cut a rough relief mural of a boxer in a pugilistic pose into the quarry face on the eastern side of John Street. This well known local landmark has long since gone to make way for futher quarrying.

A picturesque sandstone cottage is situated at 112 Slade Road. This was built sometime in the latter part of the last century. It was a small farm with orchard. It is well preserved and worth noting on a stroll through the valley as it is an interesting example of the stonemason's skills (Map ref. 7).

One of the finest examples of a Federation sandstone house can be seen at the end of March Place, Earlwood. This home, commonly called 'The Grange' is in a dominant position above The Escarpments and can be seen from Nannygoat Hill.

For the purposes of observation, as a general rule of thumb, those houses which are constructed of small sandstone blocks and/or with a smooth-faced ashlar finish are older than those using large, rough, unworked stone.

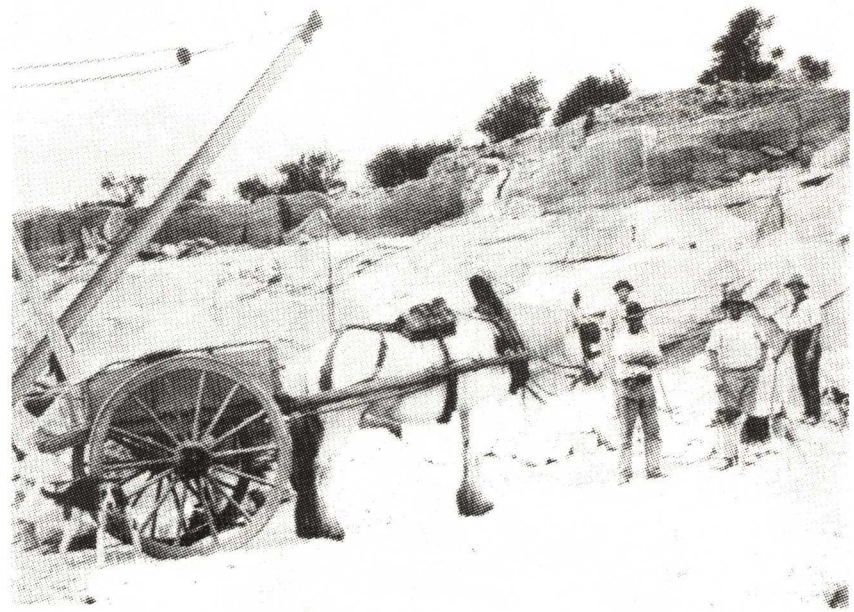
During the twentieth century sandstone was used less frequently as a building material as the Wolli Valley came to be surrounded by more modern, easier to build brick and fibro constructions. The area between Cooks River and Wolli Creek was developed from 1905. The first land-subdivision sale of 198 blocks was advertised as the Unwins Hill Estate, Tempe, later Undercliffe. It was described as being 'Magnificent Highlands with Superb Panoramic views' A further subdivision was advertised for sale in 1911. The area originally known as Forest Hill, renamed Earlwood in 1915, was subdivided and developed around this time. Many houses were built on the steep ridges in the Earlwood area, several spectacularly constructed on sandstone piers.

Sandstone quarrying in the Wolli Valley

For the early settlers in the valley the abundant supplies of sandstone amply satisfied their building needs. Most of the houses described above were constructed from local stone. When Edward Campbell's property of 110 acres between Cooks River and Wolli Creek was put up for sale in 1878, a sandstone quarry and a commodious family residence were advertised features. Stone was extensively quarried from the Turrella side of Wolli Creek during the nineteenth century, apparently only for local needs, as the sheer rock faces adjacent to Hannam Street indicate. When the area was subdivided and developed after the First World War those who planned to build houses on the floors of former quarries were offered soil by the local council.

In the last two decades of the nineteenth century there were no commercial quarrying operations listed in the Arncliffe, Forest Hill (now Earlwood) and Turrella areas. In the first decade of this century, however, the Walz business in Roach Street Arncliffe and other small enterprises were started up, as was the small operation of William Jackson in the area which is now Jackson Place.

Jackson came to Australia around the turn of the century. He was first listed in the electoral register as William Jackues, a shipwright (later a quarryman) and resident of Unwin's Bridge Road which ran along the line of what is now Bayview Avenue. His only near neighbour was Mary Campbell who lived in 'Wanstead', one of the earliest farms of the area, situated on the southern side of Cooks River at Undercliffe.



This turn-of -the-century photograph of Canterbury Quarry in River Street shows a single-horse cart of the type used in the Jackson quarry. (Courtesy Mrs Twist).

Little is known of Jackson apart from his quarrying operations, however early records of Undercliffe School indicate that he was active in local public affairs. The population of Undercliffe grew rapidly in the early part of the century. Children had to go to school across the Cooks River to Tempe PS or Marrickville West PS, a dangerous journey with floods and a railway crossing at Tempe. Jackson joined parents and local residents in petitioning the Department of Public Instruction to approve a school for the Undercliffe area. This is described in *Undercliffe Public School—50th Anniversary 1928-1978* as "...a well organised, consistent, stubborn, single-minded, and indefatigable attack on the insurmountable obstacles seemingly put forward by the Department to frustrate Undercliffe residents' ambition to acquire a school".

Approval was finally given on 31 March 1914 and and an agreement signed, on behalf of the residents, by William Jackson along with Messrs Martin, Ashby, Goodacre and Rankin. The original school was located in the Baptist Mission Church Hall in Undercliffe, until the new school was opened on its present site

Dimension stone being quarried at Gosford Quarries in 1941. Similar methods would have been used in the Schwebel quarries prior to their closure in the 1960s. (Courtesy Mitchell Library).

in 1928.

Sands Directory lists the Jackson quarry only from 1905-08 although it may well have been operational outside of that date. The excavated area is approximately 4,000 square metres. The old quarry site, set in bushland at the western end of Jackson Place, is an interesting feature of the area (Map ref. 8).

The Schwebel family was responsible for large-scale quarrying operations in the Marrickville area. In 1911 Schwebel's quarrying activities were extended to the south side of the Cooks River to Undercliffe. The vertical stone faces which are partly visible from Steel Park at Illawarra Road, are the result of these operations. The stone was used for kerbs and gutters, foundations, homes and public buildings. The runway which was constructed at Mascot airport in the 1940s was made using Undercliffe stone. Sandstone quarrying finished in the district in 1960. Some natural revegetation of the worked areas has occurred since.

Jackson Quarry today—a charming space in a bushland setting with interesting rock surfaces exposed through quarrying. It's also a great place for birdwatching! PHOTO: Melinda Menning

Prior to the use of motor transport, stone from commercial quarries was transported by horse and wagon. Stone of a very high quality, with few faults and of a hard and durable form, would often be carried across Sydney for use in public buildings and monuments. Teams of eight horses could pull stones of up to 8 tons. Many of the quarry sites required single horse vehicles because of the location and steep grades. Stone was usually moved and lifted by hand-operated winches although cranes would have been used in later years.

The lower quality stone would be used for less important work and would tend to be used in local constructions, such as footings for houses and curbing and guttering. Many of the modest sandstone houses in the Wolli Valley area are of 'rubble construction', using this accessible and less valuable sandstone. The exact source of local stone can often be traced. The blocks used in construction often contain 'birthmarks', or distinctive colours or patterns which are characteristic of particular quarry sites.

Much of the quarrying which took place in the Wolli Valley was on a small-

scale, non-commercial kind. Several people who settled in the area in the early part of this century quarried stone for building their own houses. The Price family of Highcliff Road made do with a rough wooden shack for some years, before the First World War, while Mr Price constructed a sandstone dwelling. Mrs Price placed tubs under the sandstone cliffs to collect water for washing in.

Mrs Jean Young, a long time resident of the same street, recalls the area in which she lived being strewn with sandstone rubble, some of which was from the Jackson quarry and some from other local small-scale operations. She recalls that her father would use blocks of sandstone to hold down the wire of the fowl fence only to have it stolen by a local character who made a small profit out of selling the stone.

Stonemasons and quarrymen

The art of stonemasonry is among the oldest of the manual crafts still practised today. The Stonemasons' Guilds date back to medieval Britain and had a tradition of guarding the techniques they used with a fierce secrecy, and of restricting entry into the vocation. The stonemasons were an important section of the working class in nineteenth century Australia. The legacy of their labours in fashioning the stones for monuments and public buildings can be seen in all of the nation's historic cities. They also constructed monumental headstones and 'holy stones'—soft sandstones used for scouring the decks of ships.

Evidence of the strength and solidarity of the stonemasons' guilds is indicated by the fact that they were among the first workers to win the right to an eight-hour-day. During 1855-56 the Operative Stonemason's Society, Australia's first trade union, adopted the slogan "eight hours work, eight hours play, eight hours sleep and eight bob a day". This catchcry was later taken up by the broader trade union movement as a demand for all workers. Throughout the nineteenth century it was more common for masons to be brought out from England and Scotland than for local young men to be trained in the trade.

The demand for stonemasons' skills decreased significantly during the twentieth century as cheaper prefabricated building materials came to be favoured. In 1977, however, the Public Works Department of NSW set up the Stonework Restoration Program in order to restore many of the declining sandstone buildings in NSW. They organised a team of stonemasons, many members of which had to be brought out from Britain, Italy, Portugal and Lebanon. Apprentices have been trained in stonemasonry, and skills which were

Stonemasons at work on the construction of Sydney University in 1859. Contrast the dress of the stonemason on the left with the modern apprentices in the photo on page 23. (Courtesy Mitchell Library).

almost lost in Australia have been rekindled. In the Bicentenary year the numerous restoration projects undertaken around Australia provided a boost for the craft. This has continued with work being done on many fine buildings in NSW.

The work of quarrymen was difficult and dangerous. Far less prestigious and lower paid an occupation than stonemasonry, quarry work involved risks associated with explosives and falling rocks. Quarrymen were particularly susceptible to industrial injuries. They were unionised only around the turn of the century. The rule book of the Quarrymen's Union of NSW (1911) indicates that the organisation was mainly geared toward providing accident benefits to injured members and payments to widows in the event of fatalities. Those who were

eligible to be members included "all quarrymen, gutterers, scrabblers and learners". Each had to pay a fortnightly subscription of two shillings. When a worker was injured it was required that "his mates or friends shall report his condition to the secretary or steward at least once a fortnight". As concrete and bricks have come to replace building stones during this century, and as quarrying has become more mechanised, the demand for labour has decreased substantially.

Techniques of quarrying and working sandstone

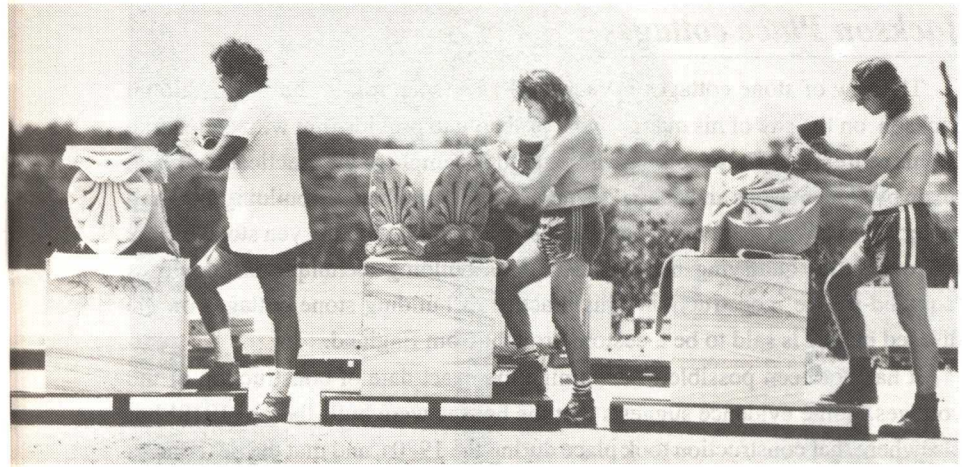
An early meaning of the word quarry is 'squared stone', hence quarrying originally referred to the production of dimension cut stone rather than simply the extraction of rock. When usable rock is found the weathered rock is stripped away. Large blocks are then separated from the parent mass with low-powered explosives. High-powered explosives would cause the rock to shatter and be useless. A floor is established and quarries are usually developed by stepping downwards from this floor. The rock is further broken down through the drilling of a line of small holes 2 cm across, 20-30 cm deep and 15 cm apart into which wedges are placed. They are driven with light blows of a hammer creating a line of tensile stress between the holes which causes the rock to split. The success of this process depends upon taking advantage of cleavage planes in the rock.

Local historian, Arthur Ellis has, vivid memories of quarrying in the 1920s. As a child he spent many a day exploring the valley (often truanting from school!). He recalls watching quarrrymen at work and describes the process of using explosives, "resembling dark rock salt" to fill the holes drilled in the stone. Later this process was made much safer when Nobel's revolutionary invention of dynamite was replaced by more sophisticated explosive techniques.

In order to cut the sandstone to required dimensions, several lines of saws were needed. This arduous process took some hours to complete. The use of diamond tipped saws in more recent times has speeded up the cutting of stone considerably.

The job of the mason is to fashion the stone to required shapes. Frequently this was done at the quarry site. Attention had to be paid to the qualities of the stone when considering its use in building. A sandstone block with a seam of mica in it, for example, might cause a structural failure in an overhanging stone.

Much of the stone used for the humble purpose of kerbing and guttering, particularly the deeply-laid corner-stones, required skill in cutting and laying. The durability of these structures is a tribute to the early workmen.



Stonemasons working at Gosford Quarries in 1994 on carvings for renovations to the Newcastle Town Hall clocktower. These stonemasons were graduates from the TAFE stonemasons course which was reintroduced in 1989. The last such course was discontinued in 1934 for lack of interest.
PHOTO : Troy Howe (Courtesy Sydney Morning Herald).

For grand public buildings only the best fault-free sandstone blocks are used. Each tool used by masons refines the work done by the previous one. They begin with heavy-duty chisels and punches. Metal templates are used to mark out the shape and outline of any decorative designs. Claw and boasting chisels render the surface more finished but with marks and scrapes remaining. Clay mouldings are used to fashion ornate designs. Finally, stone and water are used to render a smooth finish. The more labour that is put into the working of sandstone, the more smooth and ornate is the result.

In more recent times advances in techniques for working sandstone include ultra-violet retardants to protect and prolong the life of the stone and the use of epoxy (referred to dismissively as "tupperware" by the traditionally minded stonemasons), rather than the traditional clay mouldings.

Stonemasons have a tradition of leaving their individual mark on the buildings they work on. It is worthwhile studying the ornate sandstone figures on sandstone facades to pick out the quirky or incongruous aspects. A winking gargoyle or a small flower which appears to be slightly out of place may be the signatures of stonemasons who, for all their skilled labour, do not receive the recognition of the architects and politicians when the building's history is told.

Jackson Place cottages

The row of stone cottages in Jackson Place (Map ref. 9), built by William Jackson on the site of his quarry, were probably to provide him with an income for his retirement. These cottages are a unique example of the practical approach taken by stonemasons and quarry-owners in utilising whatever building sites and materials that were available. These houses were built with uneven stone blocks left over after quarrying had finished. This building technique is known as 'squared-rubble' construction. This practice of building stone cottages on the disused quarry is said to be a custom brought from England.

It has not been possible to determine the exact date of construction of the cottages. Some evidence suggests that the houses were built 'before 1918' but elsewhere that construction took place during the 1920s, and that the design was the product of a quarry owner rather than that of an architect or master builder. The oral evidence of Mrs Jean Young, long-time resident of Highcliff Road, corroborates the earlier date. She recalls visiting Jackson's daughter, Mrs Alma Sharp, in Jackson Place before the 1920s. Possibly the cottages were built over more than a decade, as space on the quarry site and building materials became available.

The houses appear to have been built as fairly rough, spartan, workers' dwellings in a style reminiscent of Scottish crofters' cottages. At first glance they appear identical but each has different features incorporated into its construction, such as window size and room layout. Alan Renaud, resident of Jackson Place for more than 60 years, believes that materials from the old 'Wanstead' homestead were used (this has now become part of local folklore). As the demolition of 'Wanstead' was advertised by the Water Board in 1922, it is unlikely that recycled materials from the old home were used in Jackson Place. However, as the exact date of completion of the cottages is not known, some materials from 'Wanstead' could have been used for those cottages completed towards the later part of the 1920s.

Lower Highcliff Avenue (later Jackson Place) first appeared in *Sands Directory* in 1929, so there was clearly some delay in registering it in the principal street directory.

William Jackson lived in No 6 Jackson Place for some years until his retirement which he spent in a more substantial, but certainly not opulent wooden house in Kingsland Road, Bexley. Alma Sharp, his daughter, lived in Number 12

No. 12 Jackson Place. Note the squared rubble construction. PHOTO: Judy Finlason.

Jackson Place until her death in about 1960. Local residents have recalled her "as someone who loved the valley, and was an environmentalist before her time".

Those among the early inhabitants of the street whose names appeared on the electoral role had their names listed as labourers or home duties.

Bill Forrest, now a resident of Bexley North, lived in Highcliff Road Undercliffe as a boy. His father worked as a stonemason in the Jackson quarry and built the solid stone foundations of their family home 'Glen Mavis' at 53 Highcliff Road. Their home was named after a valley near Bathgate, the town in Scotland from which the family migrated in 1912. Bill recalls that most of the families in the immediate neighbourhood came from England and Scotland. He well remembers the sound of bagpipes during celebrations for Hogmanay. On visits to Jackson Place and Highcliff Road. His father was active in establishing the Undercliffe Scottish Society.

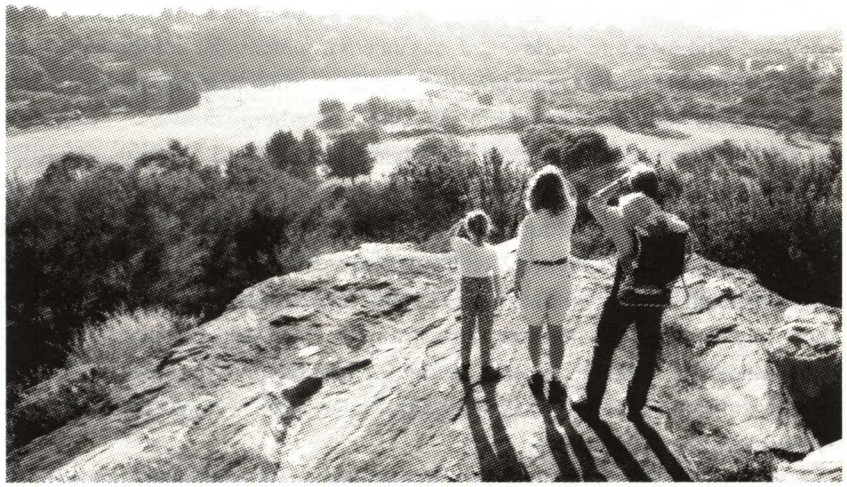
Like many others brought up in the valley, Bill looks back on the many happy days spent playing in the bush and the pranks which local boys could get up to hidden from adult eyes.

The cottages of Jackson Place remain largely unaltered and are a reminder of earlier times. Nestled beneath the quarried sandstone cliff, they are a unique part of local history and have been proposed for heritage listing by Canterbury Council.

The battle for Nannygoat Hill

Nannygoat Hill is a dominant sandstone outcrop above the reed beds and surrounding parkland of Turrella Reserve. It is visited by many walkers and is one of the best known landmarks of the valley. (Map ref. 10).

A climb to the flat rock at the top is rewarded with an almost 360 degree view to Botany Bay, the city, along the valley to surrounding suburbs and across to the Randwick ridge. The native heath and woodlands clinging to its steep rocky sides are a sanctuary for many varieties of indigenous wildlife. Nannygoat Hill would have provided a sheltered camping place for the local tribes of the area, with excellent food sources close at hand in the creek and in the dense vegetation of the valley. Shell fragments from a midden at the base of the hill are evidence of



A view from the top of Nannygoat Hill. The popular landmark is well worth a visit for its native vegetation and sandstone formations.
PHOTO: Peter Solness/ Wildlight.

Aboriginal habitation of the area.

Nannygoat Hill is a special place for many people. In 1967 it became the site of the first resident action to save the Wolli Valley from inappropriate development, when Brambles Industrial Services submitted a proposal to Canterbury Council to excavate 200,000 yards of sandstone from Nannygoat Hill. The raw material was needed for a new runway being constructed at Kingsford Smith Airport. As part of its application to Council, Brambles argued that

> There would be some annoyance and distress caused to adjoining residents if Council approved the proposal but this could be balanced on the credit side by a new recreation area of approximately 4 acres being provided.

Local residents were horrified not only at the prospect of a massive earthworks on their doorstep, but by the destruction of such a significant landmark of the valley and natural bushland.

Unused to public action, the Earlwood Progress Association and local residents, led by Mrs Elizabeth Field of Banks Road, mounted a campaign to block the move. Petitions were taken up and the local press carried lengthy reports

A 22-point onslaught

Convincing Guardianship of Nanny Goat Hill

Earlwood district petitioners convincingly protested against a recent proposal by Brambles Industrial Services to Canterbury Municipal Council for the removal of sandstone from an area known as Nanny Goat Hill.

mental that council members should obtain the views of local residents. Most of the residents in the vicinity of Nan Goat Hill were "mark people", he added.

At the council ing on Thursday, Ald the Town Clerk, M Wheeler, reported ters, had been supporting tion, had been from Mr. and Wilson, of Arth wood, and Chamb

Nanny Goat Hill Proposal Butted Out Of Council

One glimpse of Canter

200,000 yards of Sandstone sought from Nanny Goat Hill

Earlwood residents and ratepayers in the vicinity of Finlay Avenue should be aware of a major project to remove sandstone and level off the area known as Nanny Goat Hill, stressed the Deputy Mayor, Ald. Jim Beaman, recently.

$1-million public liability on contract

Ald. Beaman on Thursday, March 9 moved successfully that an application by Brambles Industrial

Brambles Industrial Services is seeking permission to remove sandstone and level off Nanny Goat Hill

weeks. Ald. Beaman emphasised that people in the vicinity should be fully aware of the "contentious"

Mulder, the Deputy Mayor Ald. Jim Beaman, and the Chief Engineer, Mr. E. N. Wilson, for the courteous hearing given to officers of the company at the

roadways construc the Department of Roads, and "commer velopments, such a structed by E. A. Wa Roselands.

The 'Campsie News & Lakemba Advance' reported on the struggle to save Nannygoat Hill during June 1967. *(Courtesy Martin Smith).*

of the progress of the application. Martin Smith, a member of the Wolli Creek Preservation Society, remembers as a young boy joining friends and neighbours on Turrella Reserve for a protest meeting. This was featured on the ABC TV program 'This Day Tonight' with popular reporter Frank Bennett. Film footage of this program has recently been found in the ABC archives.

The *Campsie News and Lakemba Advance* on 10 June 1967, under the Banner heading 'Convincing Guardianship of Nanny Goat Hill', reported that "Almost 175 residents and ratepayers crowded the public gallery, and overflowed on to the floor of the council chambers to witness the brief subdued proceedings."

A motion from Deputy Mayor Alderman Beaman that the proposal be rejected was carried unanimously on the grounds that "it would interfere with the amenities of the area and not be in the public interest".

The action of the local residents ensured that Nannygoat Hill was saved to remain the sentinel of the Valley.

Distinctive sandstone and cultural features of Wolli Valley

Those who walk through the Wolli Valley will observe a number of curious features associated with the area's sandstone.

• On the Undercliffe side of the creek (Map ref. 2) there is a sandstone overhang which is blackened by fire, this is also the site of the large scale set of 'recumbent cross-beds' (see Appendix Figure 3). Although this may well have been an Aboriginal shelter in pre-European times, it was probably used as a crude habitation more recently. During the Great Depression large numbers of homeless people lived in the bushland around Sydney. There is oral evidence that numerous such people camped around Wolli Creek in the 1930s. The area was attractive to the homeless and unemployed because of its seclusion, fresh water and access to trains to the city, essential for picking up the weekly'susso' (sustenance payment).

• A dry stone wall (Map ref. 11) which runs north-south from the eastern limit of Highcliff Road towards the Creek is located on the pre-1885 boundary which separates the Campbell grant from the Bradridge property. This boundary extended from Unwins Bridge Road (now Bayview Ave) to the creek. Dry stone walls, because they use no manufactured materials, are difficult to date.

• The weir across Wolli Creek at Turrella (Map ref. 12) is formed by a sandstone-rubble wall, faced with cement. The cement rendering was produced

Nannygoat Hill seen from the reedbeds near the Henderson Street footbridge.
PHOTO: Judy Finlason.

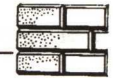
in quite recent times but the Turrella Weir was constructed prior to 1885 and may have been used as a crossing point for a considerable period before this date. Recently revegetation and clearing of weeds has exposed the original stonework. The weir is located at a point where the creek is quite narrow and within a short distance of a break in the Nannygoat Hill-Undercliffe escarpment. The weir separates the estuarine section of Wolli Creek from the freshwater section.

• At the base of the sandstone cliff (Map ref. 13) there is a murky cement-lined pool excavated into a bluff overlooking the valley. This was constructed in the 1920s by a local resident as a swimming pool. The location of what is known as 'Russell's Pool' took advantage of a steady supply of water from a soak above the cliffline which overhangs the pool.

• Sandstone building foundations (Map ref. 14) which can be located just to the west of Bardwell Park Railway station are the remains of two substantial structures which stood on the site of King's Farm. The farm was in operation before the First World War and continued for some time afterwards but had vanished by the 1950s. Pig-raising was undertaken here and a number of troughs

which were cut into the bedrock were probably used for feeding the animals.

• Between Bexley North and Bardwell Park, below Johnston Street, Earlwood, (Map ref. 15) a large sandstone construction can be seen almost hidden by dense vegetation. The history of this construction was a mystery when it was located by Graham Wilson while carrying out the archeological study for the Heritage Assessment of the valley. Thanks to further research by Arthur Ellis, the construction has been identified as the site of a primitive hut built by Andrew Bowen during the depression of the 1930s. The original dwelling, made with stones, had an extended tin roof sheltering a basic outdoor kitchen. This was where Bowen and his family eked out a frugal existence. Although he had employment on the tramways, he lived in this subsistence manner for three years, possibly a reflection of the uncertainty of employment during the depression. All that now remains is the extensive stone terracing which was probably built to create a garden and provide space for the dwelling.



Appendix

Reading sandstone

By Dr P. J. Conaghan

This appendix provides more detail on the formation of the Hawkesbury Sandstone and features of the Wolli Valley. The geological history dates back to the Triassic Period, some 237 million years ago when Australia was part of Gondwana and situated well to the south towards the South Pole.

A mighty river flowed northeast over much of the area that is now Sydney and its environs. This river was probably not unlike the modern Brahmaputra River in Bangladesh. Its flow varied with the seasons, but was generally high-volume and cold and carried large amounts of sandy sediment. This pattern was interrupted from time to time by 'mega-floods' when huge volumes of water carried vast amounts of sand. The sand, when deposited, buried and compressed became the sandstone, known to geologists as the Hawkesbury Sandstone, which is so familiar from many parts of the Sydney region, including the Wolli Creek Valley.

No-one was around to record this scene, but geologists have learnt to read the pages of the history of this mighty river in the rocks that it left behind. They work on the assumption that basic geological processes were much the same in the past as they are now. On this basis it is possible to work out what the past must have been like to explain the rocks and landforms we now see.

This section sets out to illustrate some parts of that detective work, in which the Wolli Creek Valley has its own special place. To understand it we need to understand the general processes by which sandstone is formed and some of the details of the shape that sandstone formations take. This is not only interesting in itself but is also of economic importance. Sandstone is commonly porous and permeable and sandstone formations host approximately half of the world's known reserves of petroleum (oil and natural gas) and most of the world's artesian- and ground-water.

The formation of sandstone

Weathering and erosion

Sand grains are created by the disintegration of older rocks such as granites. The various processes of weathering change and break down the rocks into

smaller particles of rock and crystal. These are then eroded by running water and wind and transported from the regions of erosion (usually uplands) to regions of deposition (i.e., sedimentary basins).

Sedimentary basins are usually large subsiding areas made up of a complex of coastal lagoons, estuaries, beaches and shallow seas. If they are inland, the environment may be dominated by shifting river channels, associated floodplains and shallow lakes, as in the 'channel-country' of south-western Queensland or the Lake Eyre Basin.

The various processes of weathering and erosion lead ultimately to the chemical and physical destruction of all but the most chemically-stable and physically-durable minerals. Of these, quartz is the most abundant in the Earth's continental crust and it makes up 74% of the total rock in Hawkesbury Sandstone.

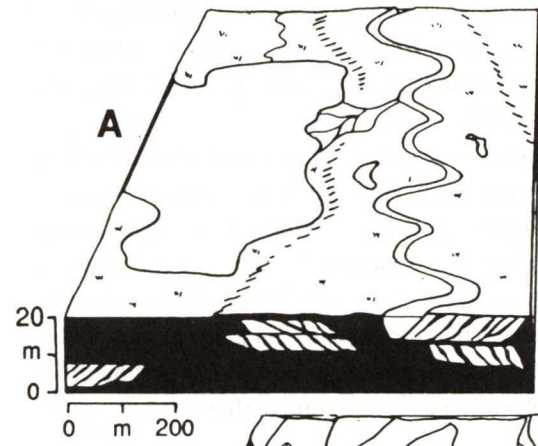
River deposits and features of sandstone

The colour and texture of sandstones depend upon the shape, size and mineralogical nature of the sand-grains and other, mainly cementing materials, from which they are formed. These in turn depend upon, among other variables, the mineralogical composition of the source-rocks from which the sand was eroded and the sedimentary environment in which the sand was deposited. In the case of sand deposited in rivers, as was the case with the Hawkesbury Sandstone, it depends on the particular type of river that was present. Rivers vary from low-gradient, highly-meandering systems (Fig. 1A) to higher-gradient, non-meandering and 'braided' river systems (Fig. 1B, C).

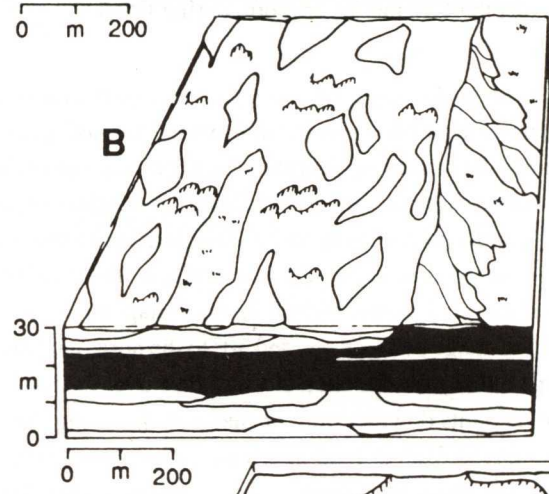
Low-gradient systems give rise to very long meandering sand deposits with widths up to a few hundred metres and thicknesses up to tens of metres. These are typically flanked by mud deposits dropped from the slow-moving floodwater (Fig. 1A). Because the river meanders, the direction of water flow, and thus the direction of the sand bodies, varies significantly.

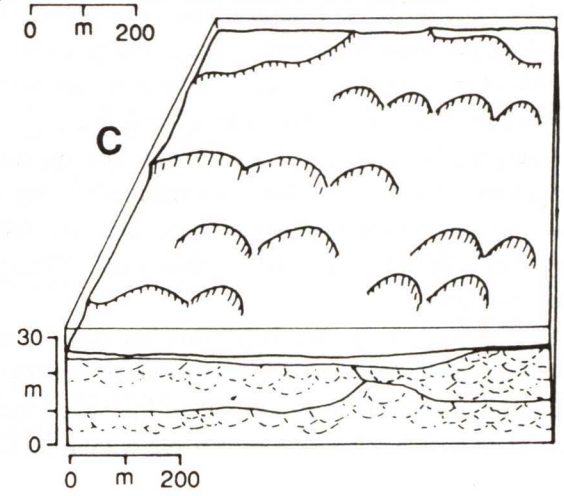
In contrast, high-gradient systems give rise to deposits that are more sheet-like, with thicknesses depending on the volume of flowing water. The water in these systems flows more rapidly and they are more prone to rapid shifts of the

Figure 1A-C. Perspective block-diagrams illustrating different river-channel patterns or 'fluvial style' (top surface of each diagram), and the resulting geometry (i.e., 'fluvial architecture') of the channel-sand bodies (white) and overbank or flood-plain mudstones (black). Vertical scale and horizontal scale (in metres) are common to each diagram. Flow direction towards observer.



A. Medium-sized meandering (high-sinuosity) river and associated complex of levee banks and flood-plain environments. Lateral migration of the channels at meander bends with time produces 'shoestring' sand bodies within a background of flood-plain mud.





B, C. Low-sinuosity river of medium- (B) and large-scale (C) and associated bedforms (i.e., braid-bars and sinuous-crested sand-waves in B, and lunate sand-waves in C). Sedimentary characteristics of the Hawkwsbury Sandstone environment suggest it was similar to C. The fluvial styles depicted in A and B characterize different levels (i.e., stratigraphic 'members') of the Newport Formation which underlies the Hawkesbury Sandstone. Diagrams modified from Cowan (1985, fig. 4.2).

channel, commonly giving rise to an anastomosing or braided channel pattern. Compared with meandering streams, they deposit smaller volumes of mud, and the direction of water flow is less variable because the channels are straighter (e.g., compare Fig. 1A with Fig. 1B, C).

In the Hawkesbury Sandstone the proportion of mudstone to sandstone is about 1:20. This, together with the shape and size of the different beds of sandstone present, enables geologists to work out the nature of the original river. They conclude that the Hawkesbury Sandstone was formed in a ~~low~~ high-gradient sandy river system, that was characterised by a very high-volume, probably seasonal, discharge. These characteristics are analogous in many aspects to the modern Brahmaputra River in Bangladesh, whose channel attains a width of 10 kilometres and a maximum depth of 30 metres or more, during flood.

Sheet sandstone

In a varying but generally even-flowing river system, sand deposits form in 'ripples' or 'dunes' at right angles to the flow, comparable to wind-formed shapes in deserts (Fig. 2A). These may be of varying heights from a few centimetres to a few metres, reflecting the volume and velocity of river flow. The height of these 'ripples' in the Hawkesbury Sandstone ranges up to 7 metres, indicating that the ancient river had a high-volume discharge. By comparison, the modern Brahmaputra shows 'ripples' up to 15 metres high in its flood stages.

The slopes of these 'ripples' range between 15° and 30° to the horizontal and the direction of steepest slope follows the direction of water flow over them (i.e., the steep side of the 'ripple' is on its down-current or 'lee' side—see Fig. 2A). These ripples give rise to inclined layers of sand which are called 'cross-beds'. Examples can be seen along the Wolli bush-track and at Nannygoat Hill. The general direction of slope of the cross-beds in the Hawkesbury Sandstone is towards the northeast, the basic direction of flow of the ancient river.

Outcrops of Hawkesbury Sandstone commonly have a sheet-like appearance, particularly when viewed from a distance. Flat planes separating layer after layer (or 'sets') of inclined cross-beds give rise to this appearance (Fig. 2B). The flat planes arise from the scouring flat of the top part of older ripple formations followed by further ripple deposits.

In some places in the Hawkesbury Sandstone there are 'recumbent' cross-beds, where the cross-bed deposits have been partially overturned (see Fig. 2C, D; Fig. 3). These can be metres high in scale and one of the largest known examples of recumbent cross-beds was recently discovered within the Wolli

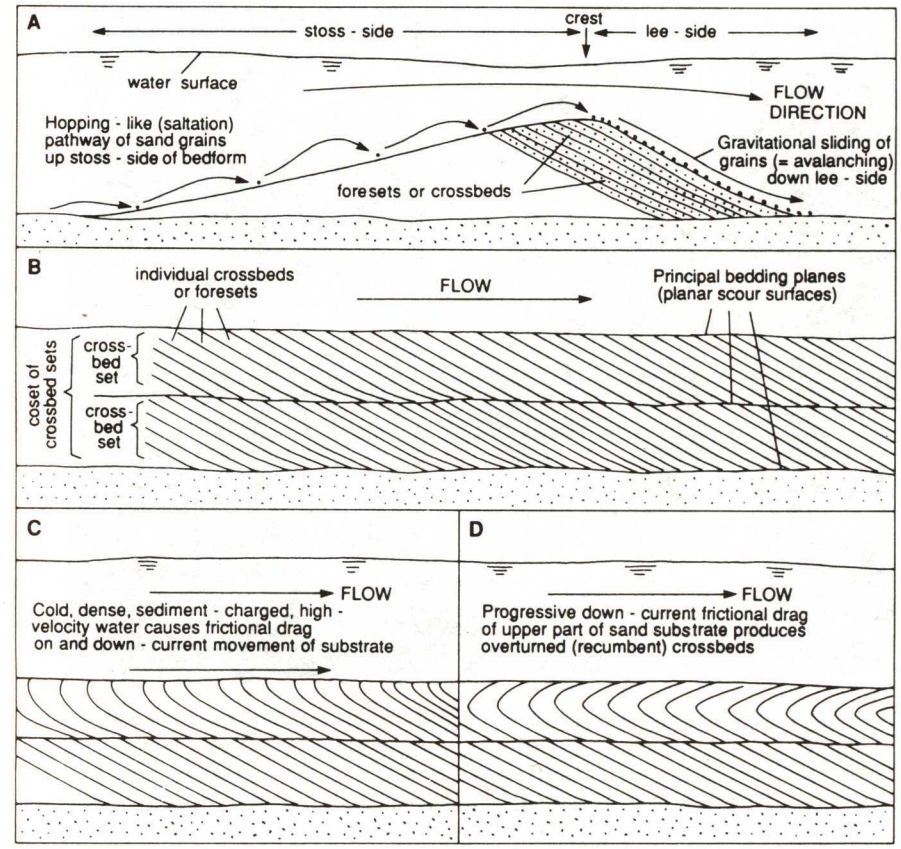

A
stoss - side
crest
lee - side
water surface
FLOW DIRECTION
Hopping - like (saltation) pathway of sand grains up stoss - side of bedform
foresets or crossbeds
Gravitational sliding of grains (= avalanching) down lee - side
B
individual crossbeds or foresets
FLOW
Principal bedding planes (planar scour surfaces)
coset of crossbed sets
cross-bed set
cross-bed set
C
FLOW
Cold, dense, sediment - charged, high - velocity water causes frictional drag on and down - current movement of substrate
D
FLOW
Progressive down - current frictional drag of upper part of sand substrate produces overturned (recumbent) crossbeds

Figure 2A–D. Diagrams illustrating the patterns of sand-grain transportation on a bedform in flowing water and the formation of cross-beds and recumbent cross-beds.
A. Cross-section showing idealised pattern of down-current sand movement in a large-scale bedform (i.e., dune, sand-wave or sand bar) and the resulting pattern of internal layering (i.e., cross-bedding) as the bedform travels down-current.
B. Cross-section of one cross-bed set stacked upon another as a consequence of the down-current passage of two large-scale bedforms, the second bedform having migrated over the eroded or planed-off deposits of the first.
C, D. Initial (C) and final (D) stages of formation of a set of overturned (i.e., recumbent) cross-beds as a consequence of prolonged strong frictional drag on the upper part of the sandy substrate under conditions of cold, dense, sediment-charged fast-flowing water.

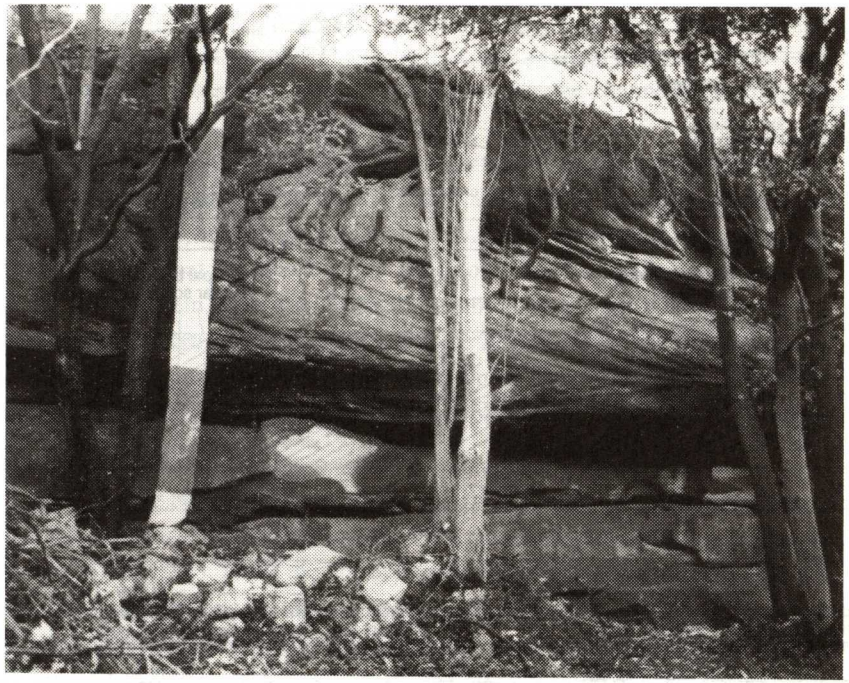


Figure 3. Large-scale cross-bed set exhibiting overturning of the cross-beds (cf. Fig. 2C, D) in the upper 1.5 m of the set (light and dark intervals on the internal banner-scale are 1 m long). This 2.5-m-thick cross-bed set comprises 'sheet-facies' sandstone and overlies 'massive-facies' sandstone (recessive interval in the lower part of the cliff; the term 'facies' means 'aspect' or 'face'—see text for explanation of these sandstone facies and compare details of photograph with Hawkesbury Sandstone Cycle in Figure 4). The direction of inclination of the unrotated lower part of the cross-beds, as well as the direction of rotation of their upper part, indicate that the flow direction of the current that formed this cross-bed set was towards the northeast (i.e., to the right in the photograph, the trend of the cliffline being west-east). Location: GR. 2842,4428, Botany Bay 1:25,000 orthophotomap (this location is directly opposite No. 17 Highcliff Road, Undercliffe). Note that the same large-scale cross-bed set and underlying massive-facies interval is exposed in the backwall of the former sandstone quarry now occupied by the houses in Jackson Place, and probably also at the top of the wall in the Jackson Quarry further to the west. This demonstrates that the large-scale cross-bed set is developed over a minimum down-current distance of about 500 m. PHOTO: Patrick Conaghan.

Valley, in the cliff below 17 Highcliff Road at Undercliffe, best seen from along the bush-track east of Jackson Place (Map ref. 2).

Geologists interpret such beds as indicating that the river has partially 'pulled over' recently deposited sand layers. This occurs when a combination of cold (and therefore dense) water and high levels of moving sediment combine to produce a high frictional drag on the bottom of the river (Fig. 2 C, D).

'Massive' sandstone

Another feature of the Hawkesbury Sandstone is the widespread presence of thick and extensive bodies of almost structureless or 'massive' sandstone. Such massive sandstones may be up to tens of metres thick. Below these layers there are commonly found irregular erosion surfaces, overlain in many places by spectacular boulders and large angular blocks of dark mudstone or shale surrounded by light-coloured sandstone.

These characteristics indicate that the materials were deposited by 'mega-floods'. Such floods eroded the upper parts of the previously-deposited sand layers. Large amounts of rock debris (such as mudstone blocks) and vast quantities of sand being swept along at the height of the flood were rapidly dumped upon this eroded surface as the flood subsided (Fig. 4).

Massive sandstone is typically medium- to fine-grained and on fresh outcrops exhibits a poorly marked, almost horizontal layering or bedding. This is usually obscured on weathered surfaces (the more common situation) and the rock appears completely structureless. Examples of such massive sandstone can be seen at a number of places along the bush-track east from Girrahween Park (Map ref. 1).

How sand becomes sandstone

The sediments which make up the Hawkesbury Sandstone were deposited in a non-marine sedimentary basin over an interval of about 2 million years between 238 and 236 million years ago (i.e., in the middle part of the Triassic Period). During long-term subsidence of the basin and burial of its deposits, the sand was eventually cemented together to form rock (Fig. 5).

The cementing material in the Hawkesbury Sandstone is clay and silica. Clay particles were deposited among the more abundant quartz grains, especially during mega-floods, and this is seen in the greater clay content of massive sandstone. In the sheet sandstone, there is less clay and the gaps between the quartz particles have been more fully taken up by silica, in the form of quartz

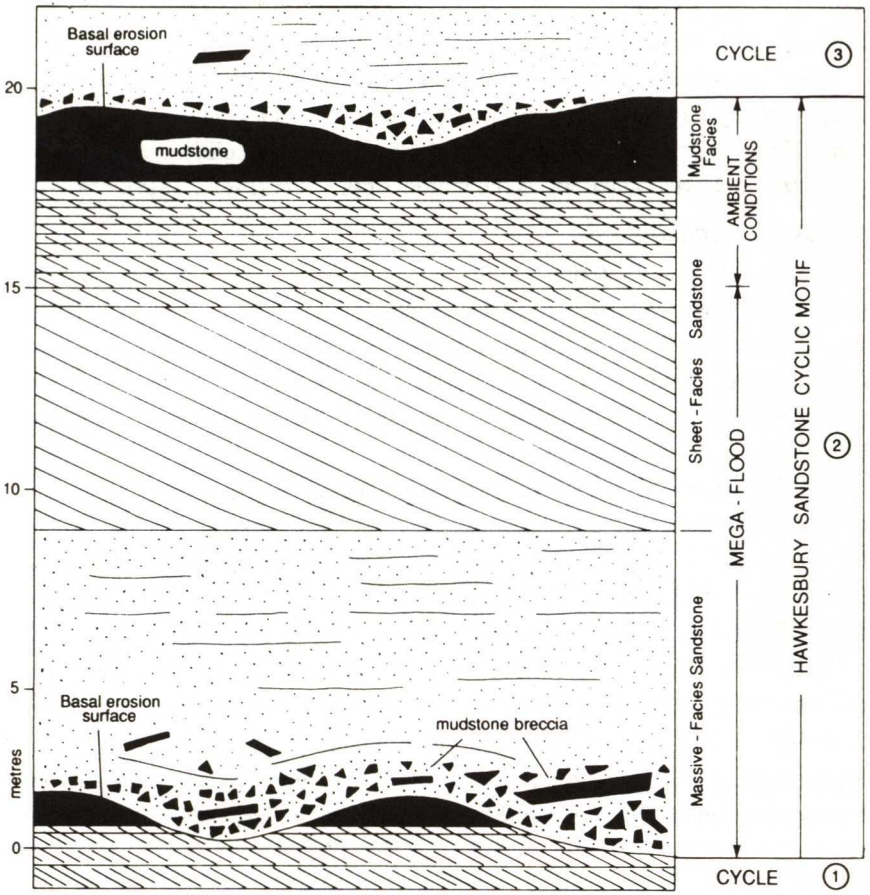


Figure 4. Idealized cross-section of the Hawkersbury Sandstone cyclic motif at typical scale (scale given in metres at left), and its interpretation (right-hand side). The flow direction of the current during deposition of the sheet-facies sandstones was from left to right in the diagram.

itself, which binds the particles more tightly than does clay. This affects the hardness and weathering characteristics of the two rock types.

The characteristic 'sparkling' effect of the Hawkesbury Sandstone also arises from the cementing process. The effect is especially noticeable where fresh surfaces are viewed in sunlight. Each tiny flashing mirror is the face of a quartz or silica crystal produced during the cementing process (Fig. 5). On any surface of the rock, thousands of such tiny crystal facets are exposed at many different

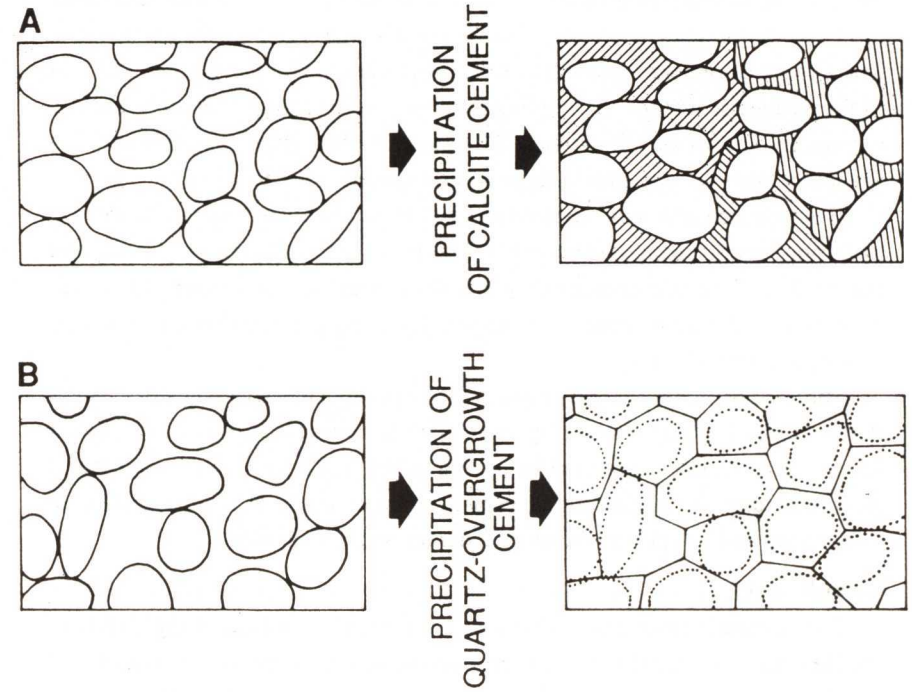


Figure 5A, B. Idealized cross-section diagrams showing the process of consolidation of sand (left-side frames) into sandstone (right-side frames), involving common cementing minerals: calcium carbonate (calcite) cement (A) and silica (quartz-overgrowth) cement (B). The calcite cement crystals depicted in A (right-side frame, three separate diagonally hatched areas) are each larger than the detrital sand grains that they enclose and bind together. In B the detrital sand grains consist of quartz and the silica cement is added on to these detrital grains (whose original outlines in the right-side frame are defined by the dotted lines) in crystallographic continuity to the quartz crystals comprising those grains. This secondary outgrowth leads to the development of new crystal facets (shown by the straight lines) on the grains enlarged in this way. This kind of silica cementation in quartzose sandstone is known as 'quartz-overgrowth cement'.

orientations to the sunlight and so 'dance' as the eye moves. The effect is more pronounced in the sheet sandstones because their lower clay content left more spaces for the growth of crystalline silica cement.

Sandstone as building material

As noted above massive sandstone typically lacks well-defined bedding planes and is uniform in texture and structure. It is quite finely grained and

incorporates a greater proportion of clay. This make-up renders it softer and easier to cut to the regular rectangular blocks most sought after for building work. Massive sandstone was, and still is, selectively quarried for this reason. The best of the Sydney sandstone for building purposes has an orange-yellow hue and is commonly known as yellowblock. This stone is often grey when first cut, but gradually takes on a yellowish tinge when exposed to the weather.

However, massive sandstone wears away more readily in response to wetting and drying and to changes in humidity. This is due to the alternate expansion and contraction of the intergranular clay as it absorbs and releases water. Where salt is present in the air or water (e.g., especially along the coastline), it develops 'honeycomb weathering'.

Sheet sandstone is coarser-grained and harder than massive sandstone. Well-defined cross-bedding planes (Fig. 4) enable it to be readily broken into irregular slabs such as the flagstones used for paving and edging in gardens etc. The coarse grain-size and the higher silica cement content make it more resistant to weathering and it typically develops a darker weathering colour.

Conclusions

It is beyond the scope of this booklet to tell more of the fascinating history of the Hawkesbury Sandstone. Yet every outcrop of the sandstone discloses to the careful observer some facet of this history, as if the outcrops were the torn and scattered pages of a book. All that is needed to read these pages are concepts of the kind outlined here and a little time to stop and contemplate the past recorded in a cliff face.

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- Wolli Creek Preservation Society Information Kit, available at local libraries and some high school libraries.
- For further information contact Canterbury & District Historical Society 407 Homer Street, Earlwood 2206, phone 718 5354 or 558 6716 or Wolli Creek Preservation Society PO Box 270 Earlwood NSW 2206, phone 567 8502.